

## CLAIMS

Having thus described our invention, what we claim as new and desire to secure by the Letters Patent is:

- 1 1. A ferroelectric capacitor comprising a conductive  
2 electrode layer; a ferroelectric layer disposed on said  
3 conductive electrode layer; a conductive counterelectrode  
4 layer formed on said ferroelectric layer and an at least  
5 partially decomposed oxygen source layer in proximity to  
6 one of said electrode layers.
- 1 2. The ferroelectric capacitor of Claim 1 wherein said  
2 conductive electrode layer and said conductive  
3 counterelectrode layer are composed of the same or  
4 different conductive material selected from the group  
5 consisting of noble metals, noble metal oxides, conductive  
6 oxides and mixtures and multilayers thereof.
- 1 3. The ferroelectric capacitor of Claim 1 wherein said  
2 ferroelectric layer is a perovskite-type oxide, a compound  
3 containing a pyrochlore structure, a potassium dihydrogen  
4 phosphate, phosphates of rubidium, cesium or arsenic and  
5 mixtures or multilayers thereof.
- 1 4. The ferroelectric capacitor of Claim 3 wherein said  
2 perovskite-type oxide has the formula  $ABO_3$ , wherein B is at  
3 least one acidic oxide containing a metal from Group IVB,

4 VB, VIB, VIIB, IIIA or IB of the Periodic Table of  
5 Elements, and A is an additional cation having a positive  
6 formal charge of from about 1 to about 3.

1 5. The ferroelectric capacitor of Claim 4 wherein said  
2 perovskite-type oxide is a titanate-based ferroelectric, a  
3 manganate-based material, a cuprate-based material, a  
4 tungsten-bronze niobate, tantalate or titanate, or a  
5 bismuth layered-tantalate, niobate or titanate.

1 6. The ferroelectric capacitor of Claim 5 wherein said  
2 perovskite-type oxide is strontium bismuth tantalate,  
3 strontium bismuth niobate, bismuth titanate, strontium  
4 bismuth tantalate niobate, lead zirconate titanate, lead  
5 lanthanum zirconate and compositions thereof modified by a  
6 dopant material.

1 7. The ferroelectric capacitor of Claim 1 wherein said  
2 oxygen source layer is a metal oxide having the formula  $MO_x$   
3 wherein M is a noble metal, a non-noble metal or mixtures  
4 and alloys thereof and x is from about 0.03 to about 3.

1 8. The ferroelectric capacitor of Claim 1 further  
2 comprising additional conductive layers proximate to said  
3 electrode, counterelectrode, or oxygen source layer,  
4 wherein said additional conductive layer is a material  
5 selected from the group consisting of noble metals, noble  
6 metal oxides, conductive oxides, metal nitrides, metal

7 silicon nitrides, metal oxides, metal oxynitrides and  
8 mixtures or multilayers thereof.

1 9. The ferroelectric capacitor of Claim 1 further  
2 comprising one or more dielectric layers formed on the  
3 uppermost layer of the capacitor.

1 10. The ferroelectric capacitor of Claim 1 wherein said  
2 conductive electrode layers are patterned or non-patterned.

1 11. The ferroelectric capacitor of Claim 1 wherein said  
2 oxygen source layer is patterned or non-patterned.

1 12. The ferroelectric capacitor of Claim 1 wherein said at  
2 least partially decomposed oxygen source layer and said  
3 electrode layer are patterned, said patterned oxygen source  
4 layer is under patterned electrode layer, and said  
5 ferroelectric layer is disposed so as to contact both top  
6 and side surfaces of said patterned electrode layer, and  
7 side surfaces of said patterned oxygen source layer.

1 13. The ferroelectric capacitor of Claim 1 wherein said  
2 structure is planar or non-planar.

1 14. The ferroelectric capacitor of Claim 1 wherein said  
2 ferroelectric layer is replaced by a layer of high-epsilon  
3 material having a dielectric constant of 20 or above.

1 15. An integrated ferroelectric/CMOS structure comprising:  
2  
3 a CMOS structure having at least one transistor;  
4  
5 a ferroelectric capacitor formed on said CMOS structure,  
6 said ferroelectric capacitor comprising a conductive  
7 electrode layer, a ferroelectric layer disposed on said  
8 conductive electrode layer, a conductive counterelectrode  
9 layer formed on said ferroelectric layer and an at least  
10 partially decomposed oxygen source layer in proximity to  
11 one of said electrode layers; and  
12  
13 at least one wiring level formed on said ferroelectric  
14 capacitor.

1 16. The integrated ferroelectric/CMOS structure of Claim  
2 15 wherein said CMOS structure further includes at least  
3 one wiring level formed over a semiconductor substrate.

1 17. The integrated ferroelectric/CMOS structure of Claim  
2 16 wherein said semiconductor substrate is a semiconducting  
3 material selected from the group consisting of Si, Ge,  
4 SiGe, GaAs, InAs, InP, other III/V compounds and organic  
5 semiconductors.

1 18. The integrated ferroelectric/CMOS structure of Claim  
2 15 wherein said conductive electrode layer and said  
3 conductive counterelectrode layer are composed of the same

4 or different conductive material selected from the group  
5 consisting of noble metals, noble metal oxides, conductive  
6 oxides and mixtures and multilayers thereof.

1 19. The integrated ferroelectric/CMOS structure of Claim  
2 15 wherein said ferroelectric material is a perovskite-type  
3 oxide, a compound containing a pyrochlore structure, a  
4 potassium dihydrogen phosphate, phosphates of rubidium,  
5 cesium or arsenic and mixtures or multilayers thereof.

1 20. The integrated ferroelectric/CMOS structure of Claim  
2 19 wherein said perovskite-type oxide has the formula  $ABO_3$ ,  
3 wherein B is at least one acidic oxide containing a metal  
4 from Group IVB, VB, VIB, VIIB, IIIA or IB of the Periodic  
5 Table of Elements, and A is an additional cation having a  
6 positive formal charge of from about 1 to about 3.

1 21. The integrated ferroelectric/CMOS structure of Claim  
2 20 wherein said perovskite-type oxide is a titanate-based  
3 ferroelectric, a manganate-based material, a cuprate-based  
4 material, a tungsten-bronze niobate, tantalate or titanate,  
5 or a bismuth layered-tantalate, niobate or titanate.  
6

1 22. The integrated ferroelectric/CMOS structure of Claim  
2 21 wherein said perovskite-type oxide is strontium bismuth  
3 tantalate, strontium bismuth niobate, bismuth titanate,  
4 strontium bismuth tantalate niobate, lead zirconate

5 titanate, lead lanthanum zirconate and compositions thereof  
6 modified by a dopant material.

1 23. The integrated ferroelectric/CMOS structure of Claim  
2 15 wherein said oxygen source layer is a metal oxide having  
3 the formula  $MO_x$  wherein M is a noble metal, a non-noble  
4 metal or mixtures and alloys thereof and x is from about  
5 0.03 to about 3.

b 24. The integrated ferroelectric/CMOS structure of Claim  
2 15 further comprising additional conductive layers  
3 proximate to said electrode, counterelectrode, or oxygen  
4 source layer, wherein said additional conductive layer is a  
5 material selected from the group consisting of noble  
6 metals, noble metal oxides, conductive oxides, metal  
7 nitrides, metal silicon nitrides, metal oxides, metal  
8 oxynitrides and mixtures or multilayers thereof.

1 25. The integrated ferroelectric/CMOS structure of Claim 15  
2 wherein said conductive electrodes are patterned or non-  
3 patterned.

1 26. The integrated ferroelectric/CMOS structure of Claim  
2 15 wherein said oxygen source layer is patterned or non-  
3 patterned.

1 27. The integrated ferroelectric/CMOS structure of Claim  
2 15 wherein said at least partially decomposed oxygen source  
3 layer and said electrode layer are patterned, said  
4 patterned oxygen source layer is under patterned electrode  
5 layer, and said ferroelectric layer is disposed so as to  
6 contact both top and side surfaces of said patterned  
7 electrode layer, and side surfaces of said patterned oxygen  
8 source layer.

1 28. The integrated ferroelectric/CMOS structure of Claim  
2 15 wherein said wiring levels include at least one  
3 conductive layer and at least one dielectric layer.

1 29. The integrated ferroelectric/CMOS structure of Claim  
2 15 wherein said ferroelectric capacitor is planar or non-  
3 planar.

1 30. The integrated ferroelectric/CMOS structure of Claim  
2 15 wherein said ferroelectric layer is replaced with a  
3 layer of high-epsilon material having a dielectric constant  
4 of 20 or greater.

1 31. A method of fabricating an integrated  
2 ferroelectric/CMOS structure comprising the steps of:

3

4 (a) forming at least one complementary metal oxide  
5 semiconductor (CMOS) device on a semiconductor wafer;

6

7 (b) forming a ferroelectric capacitor over said CMOS  
8 device, said ferroelectric capacitor comprising at least a  
9 ferroelectric layer and an oxygen source layer in proximity  
10 to a conductive electrode layer, wherein said oxygen source  
11 layer is capable of at least partially decomposing at  
12 temperatures below 700°C;

1 (c) forming wiring levels on said ferroelectric capacitor  
2 at temperatures below 450°C; and  
3

4 (d) annealing the structure at a temperature between 300°C  
5 and 700°C so as to at least partially decompose the oxygen  
6 source layer to release oxygen into the ferroelectric  
7 capacitor.

1 32. The method of Claim 31 wherein said CMOS device  
2 includes a transistor region and a semiconductor substrate.

1 33. The method of Claim 32 wherein said semiconductor  
2 substrate is a semiconducting material selected from the  
3 group consisting of Si, Ge, SiGe, GaAs, InAs, InP, other  
4 III/V compounds and organic semiconductors.

1 34. The method of Claim 31 wherein said conductive  
2 electrode layer and said conductive counterelectrode layer  
3 are composed of the same or different conductive material  
4 selected from the group consisting of noble metals, noble  
5 metal oxides, conductive oxides and mixtures and  
6 multilayers thereof.



1 35. The method of Claim 31 wherein said ferroelectric  
2 material is a perovskite-type oxide, a compound containing  
3 a pyrochlore structure, a potassium dihydrogen phosphate,  
4 phosphates of rubidium, cesium or arsenic and mixtures or  
5 multilayers thereof.

1 36. The method of Claim 35 wherein said perovskite-type  
2 oxide has the formula  $ABO_3$ , wherein B is at least one acidic  
3 oxide containing a metal from Group IVB, VB, VIB, VIIB,  
4 IIIA or IB of the Periodic Table of Elements, and A is an  
5 additional cation having a positive formal charge of from  
6 about 1 to about 3.

1 37. The method of Claim 36 wherein said perovskite-type  
2 oxide is a titanate-based ferroelectric, a manganate-based  
3 material, a cuprate-based material, a tungsten-bronze  
4 niobate, tantalate or titanate, or a bismuth layered-  
5 tantalate, niobate or titanate.

1 38. The method of Claim 37 wherein said perovskite-type  
2 oxide is strontium bismuth tantalate, strontium bismuth  
3 niobate, bismuth titanate, strontium bismuth tantalate  
4 niobate, lead zirconate titanate, lead lanthanum zirconate  
5 and compositions thereof modified by a dopant material.

1 39. The method of Claim 31 wherein said oxygen source  
2 layer is a metal oxide having the formula  $MO_x$  wherein M is

3 a noble metal, a non-noble metal or mixtures and alloys  
4 thereof and x is from about 0.03 to about 3.

1 40. The method of Claim 31 wherein said conductive  
2 electrodes are patterned or non-patterned.

1 41. The method of Claim 31 wherein said oxygen source  
2 layer is patterned or non-patterned.

1 42. The method of Claim 31 wherein said annealing step is  
2 carried out at a temperature of from about 350° to about  
3 700°C for a time period of from about  
4 1 minute to about 4 hours.

1 43. The method of Claim 42 wherein said annealing step is  
2 carried out at a temperature of from about 350° to about  
3 500°C for a time period of from about 1 minute to about 10  
4 minutes.

1 44. The method of Claim 31 wherein said annealing step is  
2 carried out in an inert gas atmosphere that may optionally  
3 be mixed with an oxidizing gas.

1 45. The method of Claim 31 wherein said ferroelectric  
2 capacitor is planar or non-planar.

1 46. The method of Claim 31 wherein the annealing step is  
2 replaced by the step of allowing said oxygen source layer

3 to decompose during steps selected from the group of  
4 ferroelectric deposition, top electrode deposition,  
5 optional encapsulant deposition, BEOL process and device  
6 operation.

1 47. The method of Claim 31 wherein said ferroelectric  
2 layer of said ferroelectric capacitor is replaced with a  
3 high-epsilon layer having a dielectric constant of 20 or  
4 greater.